Reducing the Threat of Weapons of Mass Destruction

The acquisition and potential use of nuclear, chemical, or biological weapons (so-called weapons of mass destruction, or WMD) by countries or groups hostile to the United States pose grave threats to national security. Lawrence Livermore applies its expertise in nuclear weapons to the challenge of nuclear threat reduction. Because the dangers of proliferation are not limited to nuclear weapons, Livermore leverages its extensive resources in the life and physical sciences to develop capabilities for countering the proliferation and use of chemical and biological weapons.

The attacks of September 11, 2001, followed by the anthrax mailings, revealed the vulnerability of the U.S. to terrorism. The Laboratory was able to respond effectively and broadly to those attacks because it had been actively addressing the threat of WMD terrorism for many years.

A hallmark of Livermore's threat reduction work is its integrated approach to the complex and interconnected problems of WMD proliferation and terrorism. It addresses the full spectrum of the threat—from preventing proliferation at its source, to detecting and reversing proliferant activities, to responding to the threatened use or actual use of such weapons, to avoiding surprise regarding the WMD capabilities of others.

Some of Livermore's work is directed at strengthening the technological base for those agencies with operational responsibility for implementing and monitoring arms control and proliferation prevention agreements. Nuclear nonproliferation efforts include cooperative U.S.–Russian programs to secure at-risk nuclear materials, dispose of excess highly enriched uranium and plutonium, and assist in creating self-sustaining nonweapons jobs for displaced Russian weapons workers.

Other activities are directed at understanding foreign weapons programs, identifying and characterizing proliferation-related activities, and detecting and mitigating the use of WMD against the U.S. Livermore researchers work closely with the intelligence, law enforcement, emergency response, and public health communities to develop technologies, systems, and operational capabilities that meet end users' needs and function in real-world settings.

The search for survivors at the World Trade Center using a Laboratory-developed detector.

Homeland Security Organization Created

At ceremonies in December 2002 that were widely attended by the press and local dignitaries, Director Michael Anastasio announced the creation of a Homeland Security Organization (HSO) to provide the interface between the Laboratory and the U.S. Department of Homeland Security and to ensure that the full range of the Laboratory's capabilities is available to support the Department. The new Department is tasked with reducing the nation's vulnerability to terrorism, preventing terrorist attacks within the U.S., and mitigating damage and speeding recovery should an attack occur.

HSO draws on the many scientific and technical resources at Livermore to provide a multilayered defense against catastrophic terrorism. These efforts integrate threat, vulnerability, and risk assessments with the development of advanced technologies, field-tested prototypes, and operational capabilities. Tools and technologies are developed in partnership with end users to ensure they meet the real-world needs of the federal, state, and local entities with operational responsibility for homeland security.

HSO supports six program thrusts that map onto the organizational structure of the Department of Homeland Security: nuclear and radiological countermeasures, chemical and biological countermeasures, systems analysis and studies, intelligence analysis and infrastructure protection, border and transportation security, and emergency preparedness and response. Initially, HSO is responsible for the Laboratory activities that were explicitly transferred from the Department of Energy to the Department of Homeland Security. HSO's responsibilities will evolve as the Laboratory's relationship with the new Department matures.

Penrose Albright, from the new Department of Homeland Security, spoke at the Laboratory in December 2002.

A Tribute to 9/11

On the first anniversary of the September 11 attacks, a commemorative event was held at the Laboratory's main auditorium, attended by more than 300 employees who directly contributed to the nation's response. Televised for the entire Laboratory staff, the ceremony paid tribute to those who lost their lives. It also honored the Livermore employees called to military service or deployed to assist in homeland security and counterterrorism efforts. After the attacks in 2001, the Laboratory's nuclear incident response teams were put on alert, the Threat Assessment Center went to 24/7 operation, analysts flew to Washington to support the U.S. intelligence community, and prototype instruments were taken out of laboratories and deployed in the field to help with search activities in New York and with biodefense at critical sites around the nation.

New Tools to Enhance Homeland Security

Also announced in December 2002 were two new technologies to help defend against WMD terrorism. The Analytic Conflict and Tactical Simulation (ACATS) is a spin-off of Livermore's Joint Conflict and Tactical Simulation (JCATS), which the military uses for training, analysis, mission planning, and support of actual military operations. ACATS applies JCATS' cutting-edge simulation capabilities to the scenarios that may take place in an urban setting, from the spread of a chemical or biological agent within and around buildings to the search for survivors in the rubble of a bombed building. As players and users provide input to the simulation in nearly real time, ACATS models emergency response operations. ACATS is designed for use by local, regional, and state agencies to help them prepare responses to terrorist attacks, natural disasters, and large-scale accidents.

The second new technology is the Homeland Operational Planning System (HOPS). Livermore developed HOPS in partnership with the California National Guard, with funding from the Department of Defense. HOPS is a Web-based information system that models buildings, stadiums, convention centers, landmarks, and other potential terrorist targets and helps in assessing vulnerabilities and preparing emergency response plans. HOPS can link to the National Atmospheric Release Advisory Center, operated by Livermore, to rapidly obtain assessments of the dispersal and effects of chemical, biological, or radiological attacks. In the past two years, HOPS has supported the Los Angeles County Sheriff's Department in planning for the Democratic National Convention and the California National Guard in assuring security for the 2002 World Series.

BASIS Deployment at the Olympics

Lawrence Livermore and Los Alamos national laboratories jointly developed the Biological Aerosol Sentry and Information System (BASIS) that was deployed at the 2002 Winter Olympic Games in Salt Lake City, Utah, and at several other locations around the country. BASIS uses a network of distributed air sampling units located in and around potential target sites. The samples are then retrieved and brought to a field laboratory for analysis. To ensure that BASIS supports real-world operational needs, Livermore developers worked closely with the federal, state, and local public health agencies responsible for emergency response and medical operations in the event of a bioattack.

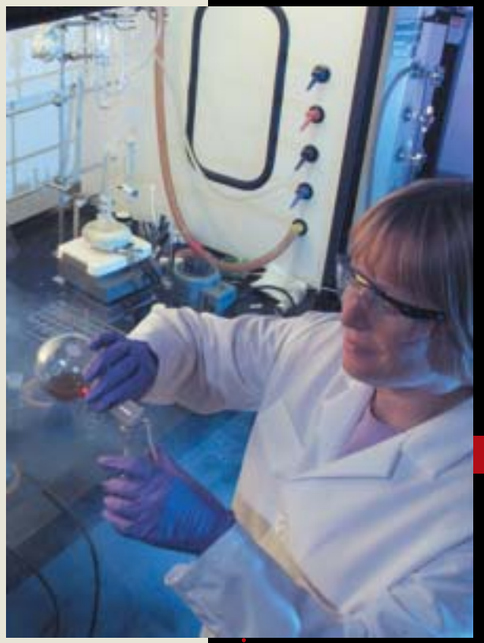
The heart of the BASIS field laboratory is the Cepheid Smart Cycler, which is based on advanced (miniaturized, real-time) polymerase chain reaction (PCR) technology developed at and licensed from Livermore. This technology reduces the time for detecting a bioagent release from days or weeks to hours. Miniaturized PCR technology is also used in Livermore's Handheld Advanced Nucleic Acid Analyzer (HANAA), the first truly portable, battery-powered biodetector. HANAA, which can provide results in 30 minutes or less, is being commercialized by the Environmental Technologies Group of Smiths Industries.

Several advanced biodetection concepts are under development. The goal of these instruments is to provide autonomous, rapid, and highly multiplexed detection and analysis of biological pathogens. For example, the Autonomous Pathogen Detector System (APDS) provides stand-alone, automated, continuous monitoring and identification of biological agents. This past year, Livermore researchers demonstrated an APDS prototype capable of autonomous multiplex detection with analysis times of approximately a minute for each measurement. Work is under way on even more advanced concepts for highly multiplexed detection (hundreds of simultaneous assays) of viruses, toxins, spores, and vegetative bacteria.

DNA Signatures for Homeland Security and Public Health

PCR instruments such as HANAA and APDS work by amplifying biological signatures—unique short stretches of DNA—for each pathogen of concern. By combining computational analyses and laboratory screening, Livermore researchers have developed "gold standard" signatures for most of the top pathogens of concern for bioterrorism, including *Yersinia pestis* (plague), *Bacillus anthracis* (anthrax), and many others. Identifying such DNA signatures is challenging because pathogens are notorious for sharing useful genes. If a DNA signature is not truly unique to its organism, some false samples will test positive. Conversely, if the signature DNA is not present in all the different strains of the target organism, false negatives will result. The signatures are validated in collaboration with the Centers for Disease Control and Prevention (CDC). In addition to their use in biological-agent sensor systems, the signatures are distributed by the CDC to the nationwide Laboratory Response Network that analyzes disease outbreaks.

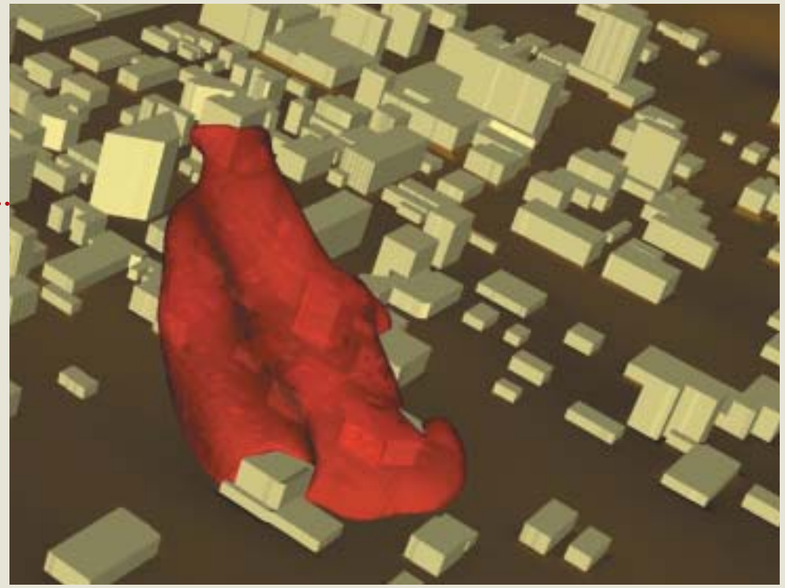
The technologies developed by the Laboratory and others to fight bioterrorism can also be used to detect naturally occurring pathogens in food, plants, and animals. Working with UC Davis and the State of California, Livermore researchers have developed tests for foot-and-mouth disease, exotic Newcastle disease (which is threatening California's poultry industry), West Nile Virus, Campylobacter (a bacterium present in undercooked chicken), and different types of Salmonella (a bacterium that can be found in eggs, juice, fruit, or vegetables). Using these DNA signatures and PCR-based detection instruments, test results can be obtained in less than an hour.



Enhanced Capabilities to Track Chemical and Biological Releases

In 2002, Livermore began working with agencies in the Seattle area to evaluate an approach for improving local emergency response capabilities. In this pilot project, local emergency management centers can link to the National Atmospheric Release Advisory Center (NARAC). NARAC is a national emergency response service for real-time assessment of incidents involving radiological, chemical, biological, or natural hazardous material. The goal of the Local Integration of NARAC with Cities (LINC) program is to provide a unified tool for city, county, state, and federal agencies to use in emergency planning and response.

NARAC can map the probable atmospheric spread of contamination in time for an emergency manager to decide whether protective actions are necessary. NARAC can also be used to evaluate specific scenarios for emergency response planning, such as optimizing the siting of bioaerosol samplers or determining evacuation routes. Since 1979, NARAC has responded to more than 160 alerts, accidents, and disasters and has supported more than 850 exercises. Recent efforts by NARAC researchers have focused on improving the simulation of biological or chemical releases in an urban environment, including the three-dimensional effects of buildings that block and channel winds.



Improved Radiation Detectors and Cargo Container Inspection

Transportation and immigration authorities have a pressing need for radiation detection technologies that can discriminate weak signals from complex backgrounds in the field. Laboratory researchers have developed handheld gamma-ray detectors that offer precise energy resolution and good sensitivity. One design (shown below) includes an identification system with the detector. The other was the product of a collaborative effort by researchers at Lawrence Livermore and Lawrence Berkeley national laboratories. Both detectors use a germanium crystal diode cooled to about 100 kelvins to achieve their excellent performance. Their small size is a result of innovative approaches to cooling the crystal without use of liquid nitrogen or a large refrigeration unit. Much more portable than other high-resolution germanium detectors, these instruments are suitable for deployment at border crossings, airports, and other locations.

A significant threat to homeland security is the possibility that a nuclear device or nuclear materials could be smuggled into the U.S. inside air, maritime, rail, or truck cargo containers. In 2002, Livermore established a national test bed for cargo container experiments, and researchers began testing the capabilities of commercially available and prototype instruments to detect nuclear materials inside loaded containers. Among the participants in the evaluation project were personnel from the U.S. Coast Guard and Bureau of Customs and Border Protection. This facility is unique in that measurements can be made on actual weapons materials inside actual shipping containers loaded with realistic cargoes.

Forensic Capabilities Support Homeland Security

Livermore's Forensic Science Center has expertise and instrumentation for complete chemical and isotopic analysis of inorganic, organic, or mixed materials such as chemical warfare agents, explosives, and illegal drugs. The center also develops microanalytical forensic techniques, field instruments, and sample-collection technologies as well as new methods for detecting and characterizing the sources of weapons materials. These capabilities are supporting Laboratory initiatives in nuclear- and chemical-weapons forensics. Livermore and Los Alamos play central roles in the Domestic Nuclear Event Attribution program, sponsored by the Defense Threat Reduction Agency. The program's objective is to enhance the nation's capabilities for determining the origin of a terrorist nuclear device and its materials.

Over the past two years, the Forensic Science Center successfully passed three rigorous proficiency tests to be certified by the Organisation for the Prohibition of Chemical Weapons (OPCW) as an analytical laboratory for chemical weapons challenge inspections. The OPCW is responsible for implementing the Chemical Weapons Convention, which outlaws the development, production, acquisition, stockpiling, and use of chemical weapons as well the transfer of chemical-weapons-related technologies. As an OPCW-accredited laboratory, Livermore will participate in analyzing samples acquired during challenge inspections of facilities of concern. OPCW designation validates Livermore's expertise in chemical analysis and detection and places the Laboratory's response capabilities at the forefront in the event of a chemical threat, terrorist or otherwise.

(at left) Eleanor and John Lawrence (son of Laboratory co-founder E. O. Lawrence) visit the Forensic Science Center.

Construction of the International Security Research Facility

In April 2002, ground was broken for the $24.6-million International Security Research Facility. The two-story, 64,000-square-foot building will house some 180 people, with space for offices, electronic archiving, a flexible secure conference center, an information-processing hub, an imagery exploitation laboratory, a communications vault, and an emergency operations center. This new facility will enable the Laboratory's intelligence analysts to take advantage of the digital revolution in the intelligence business and will accommodate expanding programmatic needs for secure work space. Occupancy is scheduled for late 2004.

(left to right) Melanie Elder and Bruce Tarter of Livermore, Representative Ellen Tauscher, UC Vice President John McTague, and Rhys Williams of the Department of Energy.